Department of Civil, Construction
and Environmental Engineering

NC STATE UNIVERSITY

Road Sign Deterioration and Management

Results of NCDOT Research

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2006 NCDOT TRAFFIC ENGINEERING CONFERENCE
FOR OPERATIONS AND SAFETY

Research Background

- Research period: July 2004 to June 2006
- Research group led by Dr. William Rasdorf and Dr. Joe Hummer at North Carolina State University
- Research in response to proposed FHWA minimum sign retroreflectivity standards

Research Goals

To provide a road sign replacement simulation program that NCDOT can use to:

- Judge compliance with the proposed FHWA standards
- Optimize NCDOT sign management activities

To create the simulation program, the research team:

- Modeled the performance of NCDOT sign inspectors
- Determined sign retroreflectivity performance with age
- Determined external factors that affect sign performance

End goal: minimize number of non-compliant signs

Data Collection Procedure

- Visited Divisions 2, 6, 8, 12, and 13 January-April 2005
- Measured white, yellow, red, and green signs
- Focused on Type I (Engineering Grade) and III (High-Intensity) sheeting

Data Collection Procedure

Nighttime Inspection Visual Evaluation

Ride with sign crews during inspection

Daytime Retroreflectivity Evaluation

Measured retroreflectivity of signs from nighttime evaluation using a retroreflectometer

Data Collection Results

Nighttime Inspection Visual Evaluation

- Record number and location of signs rejected
- Note reason(s) for sign rejection
- Track route followed

Daytime Retroreflectivity Evaluation

Division	Sign Sheeting Type			
	Type I	Type III	Other	Total
2	102	20	-	122
6	232	82	2	316
8	118	17	1	136
12	112	67	4	183
13	218	79	3	300
Total	782	265	10	**1057**

Research Results

- Inspector Performance
- Sign Damage
- Sign Replacement
- **Sign Deterioration**
- **Sign Management Simulation**

Inspector Performance

How well do sign crews identify non-compliant signs?

Color	Percent of Non-Compliant Signs Identified
White	15%
Yellow	30%
Red	48%
Green	14%

Sign Damage

Black Substance on Sign

Paint Ball Vandalism

Paint Ball/Egg

Water Damage

Tree Sap

Sign Damage

Annual sign damage rate includes damage identified during nighttime inspection and other inspections

Replacement Reason	Annual Replacement Rate (%)
Natural Damage	1.1
Vandalism	2.9
Total	**4.0**

Secondary roads tend to have the most damage

Sign Replacement: 2005 to 2006

In the NCSU sample:

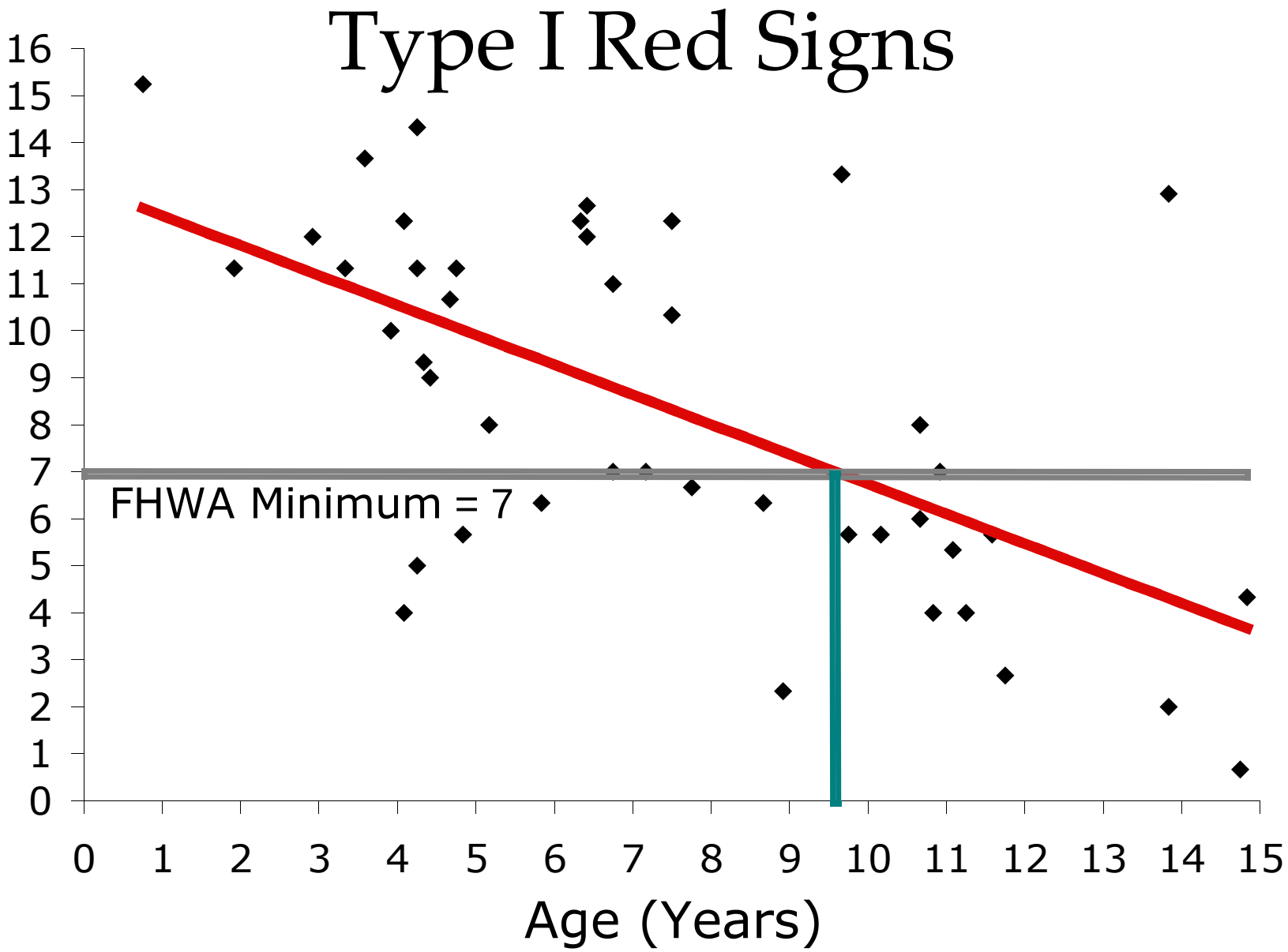
- **18%** of signs replaced
- **89%** of signs replaced with Type III
- **40%** of signs were Type III in 2006, up from 28% in 2005
- **48%** of signs replaced were not rejected by sign crews
- **44%** of signs rejected in 2005 were not replaced within one year

Sign Deterioration

Black Sign or Green Sign?

Sign Deterioration

- Deterioration with age determined for eight combinations of sign color and sheeting type
- Found no significant correlation between sign age and retroreflectivity
- However, we found that retroreflectivity generally declines linearly over time


Type I Red Signs
FHWA Minimum = 7
Age (Years)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

Sign Replacement Simulation

- Models how groups of similar signs decline in retroreflectivity and are replaced
- Signs placed into groups based on retroreflectivity, sheeting type, and color
- Calculates the annual condition of the sign population and the annual sign turnover
- Results validated by comparing them with current field sign data and NCDOT financial data

Simulation Inputs

- Derived from field data
  - Sign retroreflectivity deterioration rates
  - Replacement rates
  - Damage rates
  - Distribution of sign colors and sheeting types in the field
  - Nighttime inspection frequencies
  - NCDOT average sign installation costs
- Simulation is run until it stabilizes

Simulation Scenarios

30 Scenarios considering varying:

- Sign maintenance strategies
  - Visual nighttime inspection
  - Retroreflectometer measurement
  - Expected Sign Life
  - Blanket Replacement
- Sign rejection thresholds
- Type I to Type III conversion rates
- Inspection Frequencies

Simulation Results

- The 'ideal' sign management scenario minimizes maintenance costs and the number of non-compliant signs
- Current NCDOT practice results in **$3.56/sign** and **19%** non-compliant
- Improving sign crews' rejection threshold results in a cost of **$3.78/sign** and **9%** non-compliant

Conclusions from Simulation

- The visual inspection method is the most cost-effective sign maintenance strategy
- With training, a 10% increase in sign costs could reduce non-compliant signs from 19% to less than 10%
- The NCDOT policy of 100% Type III replacement is an effective strategy for reducing the percent of non-compliant signs
- Current inspection frequency is adequate

Recommendations

- Regular daytime sign inspections can reduce the number of damaged signs between nighttime inspections
- Sign budgets need to be large enough for sign crews to reject all non-compliant signs
- Sign crews need additional training to bring their visual assessments in line with the proposed FHWA standard

Recommendations

- More consistent inspection frequencies across all Divisions needed
- Standardize the level of sign damage that warrants rejection
- Develop a needs-based budgeting system
- Improve sign replacement costs bookkeeping

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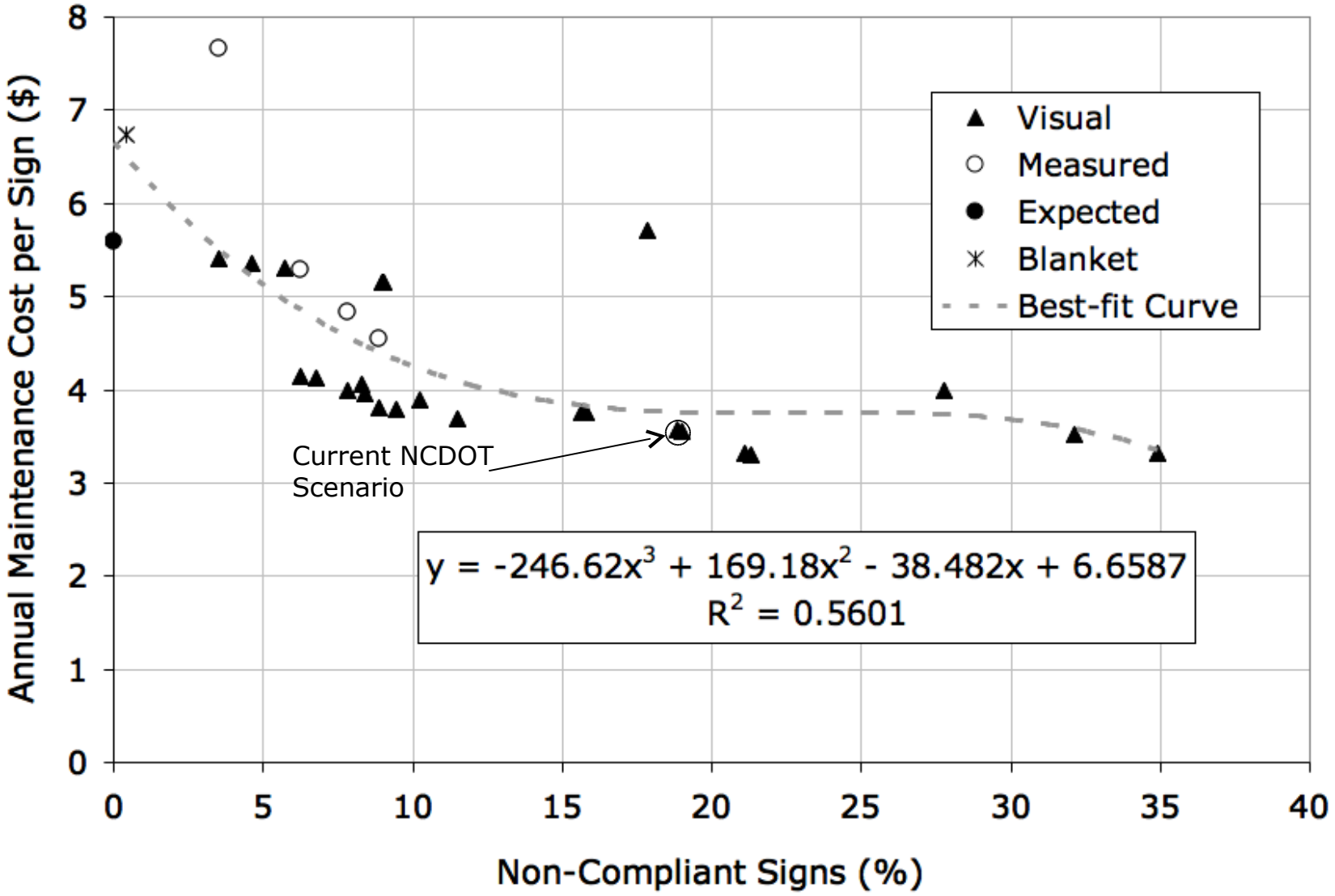
Annual Maintenance Cost per Sign ($)
Non-Compliant Signs (%)
0
1
2
3
4
5
6
7
8
0
5
10
15
20
25
30
35
40
Visual
Measured
Expected
Blanket
Best-fit Curve
Current NCDOT
Scenario
y = -246.62x3 + 169.18x2 - 38.482x + 6.6587
R2 = 0.5601